DETERMINATION OF DIFFUSION IN THE METEOR ZONE

A. Ryskulov

ABSTRACT. The results of the measurement of the coefficient of ambipolar diffusion in the meteor zone are presented.

This paper presents the results of the measurement of the coefficient /63
of ambipolar diffusion in the meteor zone, obtained by an SOM-1 radar in 1964-1965. The measurements were made over a five to eight day period of each month in accordance with the unified, agreed, IQSY program.

The equipment used for the research is described in reference [1]. The area illuminated by the antenna and in which diffusion was studied, was of the order of 300 x 300 km.

Meteors entering the earth's atmosphere hourly burn up and leave a cylindrical trail. This trail is broken up by diffusion, recombination, and electron adhesion processes, by ionospheric winds, and the like.

The experimental data tell us that the duration of meteor trail reflections varies from 0.02 sec to 1 min. This is explained by the fact that meteors have different masses and velocities which determine the electron line density in the trail.

T. Kaiser and R. Klaus have shown that two types of meteor trails are distinguishable according to electron density.

The first includes meteor trails with electron density $\alpha < \leq 2.4 \cdot 10^{12}$ e/cm, called underdense trails. The diffusion coefficient for these trails can be determined from

$$D = \frac{\lambda^2}{16\pi\tau_{0.5}} \qquad (1)$$

where

λ is the wavelength;

$\tau_{0.5}$ is the duration of the reflection from the meteor trails at the 0.5 level.

The second group of meteor trails includes trails with electron density $\alpha \geq 2.4 \cdot 10^{12}$ e/cm, called dense trails. The diffusion coefficient for /65

these trails is determined from [2, 3]

$$D = \frac{\lambda}{16\pi^2(s-1)} \cdot \frac{ln \cdot \frac{N_1}{N_2}}{(\tau_2 - \tau_1)}, \qquad (2)$$

where

N_1 and N_2 are the numbers of reflected signals with duration $\tau \geq \tau_1$ and $\tau \geq \tau_2$;

s is the index of the degree of meteor mass distribution, equal to

$$s = 1 + \frac{4}{3} \frac{ln \frac{N_1}{N_2}}{ln \frac{\tau_2}{\tau_1}}.$$

Trails of the intermediate type were not used for the calculation [5].

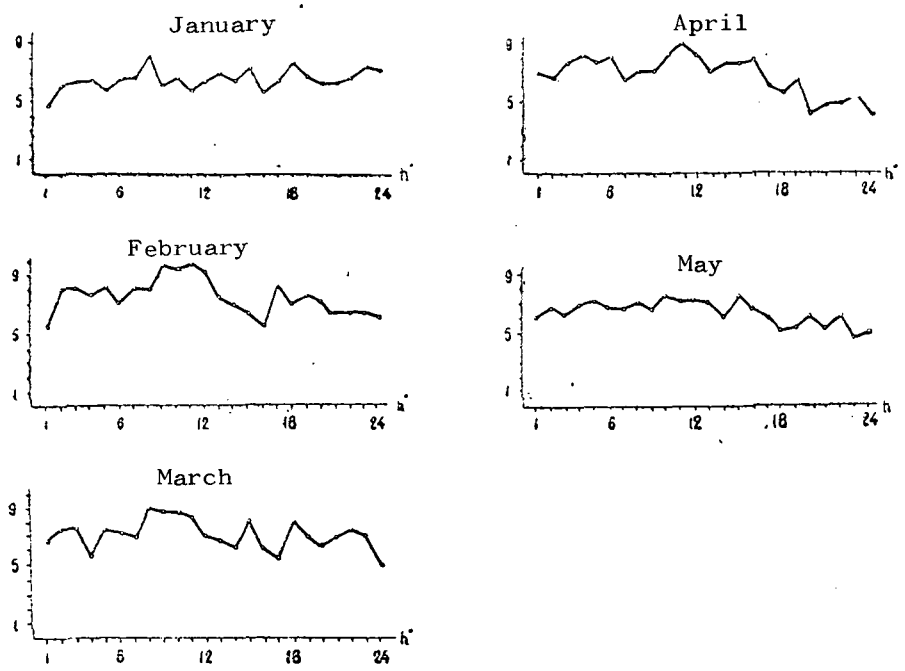

Figure 1. Daily changes in the diffusion coefficient.

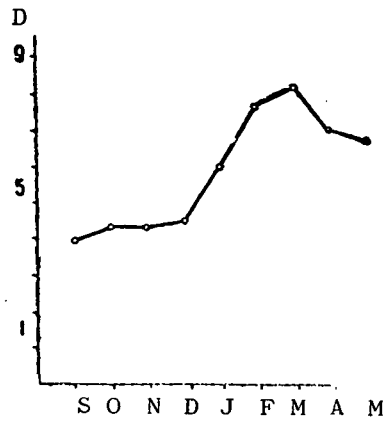

Figure 2. Seasonal changes in the diffusion coefficient for 1964-1965.

Figure 1 shows the daily changes in the diffusion coefficient for 1965, calculated using Eq. (1) for underdense trails. Summing the data without altitude separation resulted in a wide scatter in the hourly diffusion values.

The curves in Figure 1 show that the mean daily coefficient of ambipolar diffusion is approximately $D \approx 6\text{-}8$ m^2/sec. /66 There were individual months when the daily diffusion rate had an amplitude of the order of 3 m^2/sec, with the diffusion maximum occurring during the morning and daylight hours, something that evidently is associated with expansion of the atmosphere and reduction in the density at the corresponding altitudes.

Figure 2 shows the seasonal change in the diffusion coefficient for 1964-1965. The diffusion coefficient minimum occurs in the winter months ($D \approx 4$ m^2/sec) and the maximum in the summer ($D \approx 7$ m^2/sec). This change may also be caused by the heating action of solar radiation.

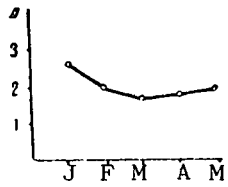

Figure 3. Seasonal change in the diffusion coefficient for over-dense trails.

Figure 3 shows the seasonal change in the diffusion coefficient, calculated using Eq. (2) for dense trails. The mean diffusion coefficient is approximately $D \approx 2$ m^2/sec. This difference in diffusion coefficients for underdense and dense trails for the same hour and month of study shows the inaccuracies in Eq. (2) and the significantly greater scatter in the altitudes of reflecting points for dense trails and of the application of different effects (polarization, resonance, fading, and wind) on the determination of the duration of trail existence.

In our opinion, diffusion coefficients should be measured using Eq. (1) only for a limited altitude (90-95 km), as B. L. Kashcheyev [4] has already pointed out.

Conclusions

1. The mean diffusion coefficient for the underdense type is approximately $D \approx 6\text{-}8\ m^2/sec$, with a daily amplitude of the order of $3\ m^2/sec$.

2. The values of the diffusion coefficient increase in the summer months by a factor of 1.5 as compared to the winter values.

REFERENCES

1. Karimov, K. A., Kostromin, V., Berezovskiy, M. I., "Radar Installation for Observing Meteors in Kirghizia," Sb.: Meteornoye rasprostraneniye [Collection: Meteor Propagation], Kazan', 1966. /67

2. Fialko, Ye. I., Nekotoryye problemy radiolokatsii meteorov [Some Problems of Radar Observations of Meteors], Tomsk, 1961.

3. Peregudov, F. I., Kharakteristika meteora, kak radiolokatsionnoy tseli [Characteristics of a Meteor as a Radar Target], Tomsk University Press, 1960.

4. Kashcheyev, B. L., "Investigation of the Properties of the Upper Atmosphere by Radar Observations of Meteors," Sb.: Meteory [Collection: Meteors], 2-3, KhPI, 1963.

5. Fialko, Ye. I., "A Method for Measuring Electron Line Density and Diffusion Coefficient Using Meteor Radio Echoes from an Intermediate Body," Geomagnetizm i Aeronomiya, 1965.